

A STUDY IN APHASIA.

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A full understanding of the function of Broca's centre necessitates the knowledge of its relations not only to articulate speech but also to the faculties of reading and writing.

It will be remembered that Wernicke⁹ compared the process of acquiring speech to a reflex process, saying that each auditory impression deposited in the so-called auditory speech centre evoked the corresponding motor concept required for the utterance of the corresponding sound or word. The part which visual, tactile and muscular or kinæsthetic sensation may play in the acquisition was not at all considered by this author. Only Wyllie has called attention to this point.

A careful analysis, indeed, shows that the visual, tactile and kinæsthetic elements have a much more direct influence upon the acquisition of speech than the auditory element.

The importance of the visual impressions is suggested by the fact that those articulatory motions which the child can most easily observe in others, namely, those acquired for the utterance of the lip sounds, as "papa," "mama," etc., are first learned, and that those which escape direct observation, as for instance, the k and the German ch, cause often the greatest difficulty. When we teach a child to repeat a word, we can notice that it looks attentively at the speaker and observes the motions made in uttering the sound.

Let me quote another no less characteristic instance.

⁹Wernicke: Der aphasische Symptomencomplex. Breslau, 1874.

The German *r* differs from the English *r* in sound. While the German *r* is produced by holding the apex of the tongue against the anterior part of the hard palate and letting it vibrate in this position, the enunciation of the English *r* requires an upward and backward rolling of the tongue during the vibration. The German may live among English-speaking people without ever learning the correct enunciation of the *r* and, principally for this reason that, although hearing the difference of the two sounds he does not know and especially not see wherein the difference of the required motion of the tongue lies. I, for my part, only learned to enounce the English *r*, at least approximately, after the backward rolling of the tongue had been demonstrated to me *ad oculos*.

But, of course, tactile and muscular sensations must be added to the visual impressions in order to enable the correct execution of the sound.

Let me further call attention to the fact that when we foreigners are taught to articulate the English *th*, the teacher shows us in what position the tongue has to be held and what motion it has to perform.

The part which the various sensations play in the acquisition of articulate speech may be expressed in the following manner:

"The auditory element serves largely to inform the person speaking whether his utterance is such as he intended it to be, while the visual, tactile and kinæsthetic elements, by modifying motor innervation, help to make such utterance possible and by degrees more and more correct." It is evident that a complicated process of co-ordination and fusion must occur here. We must further assume that Broca's centre participates directly or indirectly in this process and that the products of the fusion, the psycho-motor images of speech, are deposited in this centre.

Each word that we utter aloud is heard by us; but even if we speak only mentally, inwardly, we equally receive a distinct auditory impression of the internal utterance. In other words, each innervation of Broca's centre is conveyed also to the centre for the auditory word images, and every other sensory image which becomes associated with a psycho-motor image of speech, is at the same time associated with the corresponding auditory image. It

cannot be said on the other hand that each innervation of the auditory centre is carried to Broca's centre, as the auditory image of a word or letter need not necessarily arouse the corresponding psycho-motor image. We shall see presently that these facts are of importance for the understanding of the mental process by which we read and learn to read.

The task imposed upon the child who learns reading is to associate the visual image, say, for instance, of the letter "c," both with the psycho-motor concept required to utter the sound "c" and with the auditory image of this letter. It may be seen from the foregoing statements that the association of the visual image with the psycho-motor image of the letter "c" implies that the former is associated with its auditory image, since the latter is invariably coinnervated with each innervation of the psycho-motor image. A direct association between the auditory and the visual image seems, therefore, not absolutely necessary for the mental act of reading, and it may even be doubted whether such direct association becomes established. It is very probable, on the other hand, that a direct association forms between the visual and the psycho-motor image, which latter then coinnervates the auditory image. The understanding of the text read is brought about by an analysis of the series of auditory images evoked in the manner described.

Self-observation convinces us that the innervations take place in the serial order described. When we read, we have the distinct impression that not the "sounds," but the psycho-motor images of the words are first aroused and only secondarily the sounds." In other words, the visual image is directly transmitted into internal language, no matter whether we read aloud or mentally, and the symbols of written or printed language have only a meaning for us in connection with the internal language; they lose their meaning, as soon as the internal becomes impossible.

It is evident from these facts, that although the mental analysis of the text read occurs from the auditory images, the faculty of reading depends in the same degree upon the intactness of Broca's area as it does on the intactness of the centre of the auditory word representations. As soon as the visual image cannot be transmitted into inter-

nal language, both loud and mental reading become impossible. For this reason lesion of Broca's centre must cause, not only motor aphasia, but also alexia, not only the impossibility of loud reading but also that of mental reading; the characters and words are perfectly without meaning for such patients. On the contrary, subcortical motor aphasia leaves the internal language and, consequently, also the faculty of mental reading intact, while loud reading is, of course, also impossible in this form of aphasia.

Dejerine¹⁰ and Mirallié have come to the same conclusions on the ground of ample clinical evidence. They tested the faculty of reading in fifteen cases of cortical motor aphasia. In all these cases disorders of mental reading (*troubles de la lecture mentale*) were found. Eight of these are now cured of their alexia and three of them cured of their aphasia. At the beginning of the disease the letters had no sense for them, they saw only black on white. In the seven other cases there are still distinct disturbances of mental reading and in none of these cases speech has become normal as yet. Three cases of cortical motor aphasia were observed by one of these authors in highly cultured individuals of very high social standing, and in all three patients the alexia was present in a very marked degree.

The manner in which a child learns to read written signs does not differ from that in which it acquires the knowledge of printed characters, but of course both kinds have to be learned if the child is to be able to read and write written characters. The technique of writing could be learned to perfection without knowledge of the letters and words as symbols of language. The motor writing concepts can, therefore, be acquired without any association with the speech mechanism. Such association must occur, however, in any kind of writing except purely mechanical copying.

Part of the process underlying spontaneous writing is probably identical with that underlying writing by dictation, in this sense, that we mentally dictate the words we

¹⁰Dejerine et Mirallié: *Comptes Rendues de la Société de Biologie*, 1895, p. 523.

intend to write. In spontaneous writing the motor-speech centre is started into action by the concept which we wish to express. From the motor-speech centre the impulse passes to the centre of the auditory word representations, evoking the auditory image of the word to be written. The auditory image excites the corresponding graphic concept.

In writing from dictation we first receive auditory impressions, "sound images" are deposited. The further task is, to fix the chain of auditory images received, to remember the words or sentences heard. This fixation is evidently established by help of the internal language. We inwardly repeat what we heard and by a mental analysis establish landmarks, enabling us to reproduce the auditory impressions received in the correct serial order. The further steps are the same as in spontaneous writing. We mentally dictate to ourselves the text remembered by innervation of the motor-speech centre, etc.

It may be asked whether this process must invariably be gone through, or whether it may be shortened in such manner for instance, that the auditory images of the language dictated would evoke directly the corresponding graphic concepts. Such explanation must be excluded *a priori* where whole sentences are concerned. It cannot apply either to the writing of whole words to dictation. The writing of a word implies the ability to spell it, as we must write down the single letters composing the word in correct serial order. In other words, we must also mentally dictate to ourselves each single letter of the word, which again requires the co-operation of the motor-speech centre. For the writing only of single letters to dictation the possibility remains, that the auditory image of the letter evokes directly the corresponding graphic concept, and that consequently in this case the co-operation of the motor-speech centre may eventually be dispensed with.

Quite similar reasonings apply to the faculty of copying. Every kind of copying except that which is purely mechanical, as for instance the copying of perfectly foreign signs (say, Chinese), requires the transmission of the signs into internal language. Consequently cortical motor aphasia implies not only alexia but also agraphia, with this restriction, that the faculty of such purely mechanical copying as is equal to the copying of perfectly foreign characters, is

preserved, and probably¹¹ also the faculty of writing single letters to dictation.

Freud¹² has recently called attention to the important part which functional disturbances play in the causation of aphasic disorders, even in those cases where organic lesions are the primary cause. Bastian's theory on the various degrees of diminished function of a centre has partly served as a basis for his deductions.

Bastian¹³ distinguishes three states of lessened excitability of a centre. The slightest reduction of function expresses itself in such manner that this centre does not respond any more to volitional excitation, but can still be excited by association from one centre to the other, as also by direct sensory impulse. In the second degree of functional disturbance the centre responds only to direct sensory stimuli, while in the most severe or third degree even sensory stimuli fail to excite its functions.

Freud conceives the anatomical arrangement of the cortical speech mechanism as follows: "The speech apparatus presents itself as one continuous cortical district of the left hemisphere, situated between the cortical endings of the auditory and optic nerves and of the motor-speech and arm fibres. Any lesion within this zone of language will display its influence not only upon one single function, articulate speech for instance, but will also debilitate to some degree all the other functions of language, producing one of the states referred to by Bastian.

Freud claims that the various components of his zone of language, such as Broca's area and the centres of the auditory and of the visual word-images, are connected with one another by means of fibres which do not leave the cortex in their course. He therefore concludes that

¹¹This view is confirmed by the investigations of Thomas and Roux (*Travail du service du Dr. Déjerine. Bull. Soc. Biol.*, 1896, p. 210-213). In three cases of cortical motor aphasia these authors found that the patients were absolutely unable to write whole words to dictation; but they could write them, if each letter was dictated singly. This fact makes it appear as not only probable, but almost certain, that the faculty of writing single letters to dictation remains intact in cortical motor aphasia, as long as the motor-graphic memories are unimpaired.

¹²Freud: *Zur Auffassung der Aphasien.* Wien, 1891.

¹³Bastian: On different kinds of Aphasia. *Brit. Med. Journal*, Oct. 25th and Nov. 5th, 1887.

Brain as an Organ of Mind. *International Scientific Series*, 1880.

every aphasia must be due to disturbances within the cortex itself, saying that subcortical lesions may cause dysarthritic disorders but no actual aphasias. This view must be considered as erroneous, since, on the contrary, subcortical disease may produce the purest type of motor aphasia.

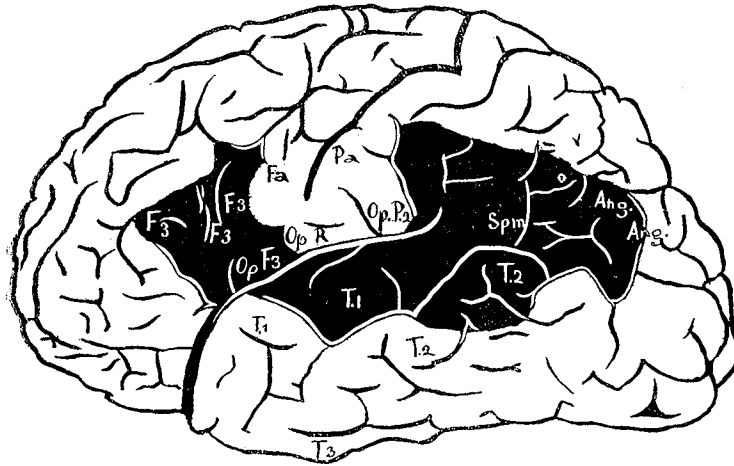


Fig. III.—Drawing illustrating Dejerine's zone of language, reproduced from Dejerine's drawing

- Zone of language.
 Fa. Anterior central convolution.
 Pa. Posterior " "
 F 3. Third frontal " "
 Op. F 3 Opercular portion of the third frontal convolution.
 Op. Pa 2. " " " inferior parietal " "
 Op. R " " " central convolutions.
 T 1. First temporal convolution.
 T 2 Second " "
 T 3 Third " "
 Sp. m Supermarginal gyrus.
 Ang. Angular gyrus.

Mirallié and Déjerine¹⁴ accept Freud's view of a continuous zone of language, within the dominion of which fall Broca's centre, the centre of the auditory word memories and that of the visual word memories. But these authors ascribe a smaller extent to this zone than Freud does.

¹⁴Mirallié et Dejerine: *L'Aphasie sensorielle*. Paris, 1896.

It is beyond doubt that the three centres mentioned are in such intimate functional relations with each other that lesion of one of them invariably tells upon the others. Thus alexia is caused not only by lesion of the centre of the visual memories but also by that of the psycho-motor images of speech; agraphia is caused not only by disease of the centre of the auditory word memories, but also by alteration of the motor speech centre; the internal language becomes impossible not only by lesion of Broca's centre, but also by lesion of the centre of the auditory word memories, etc.

Yet this physiological relationship between the said three centres does not necessitate an anatomical contiguity or continuity of the three. Elder's observation speaks indeed against such continuity and against the view of a contiguous and continuous zone of language in general, since in his case in spite of an extended defect in the central part of Freud's and Dejerine's zone of language, no aphasic, but only dysarthritic disturbances were present.

In returning to our case let us see what application we can make of the deductions arrived at. It will be remembered that at the time of the first examination the patient presented only slight disturbances of speech, but very marked disorders of the faculties of reading and writing. According to the patient's report, however, she must have had a perfect loss of the faculty of motor speech and she began to regain its use as late as two and a half months after the apoplectic attack causing the aphasia and the symptoms accompanying it. It has been shown to what an extent the functions of reading and writing depend on the intactness of the so-called motor-speech centre. We can, therefore, easily understand the coincidence of the motor aphasia with alexia and agraphia in our case, if we assume that the lesion underlying these disturbances involved Broca's centre. The absolute intactness of vision and of the visual memories excludes the possibility of a lesion in the occipital lobe. The view that a lesion of Broca's centre gave origin both to the aphasia and to the alexia finds further support in the fact that many cases of motor aphasia with alexia have been reported in which the aphasia had been almost entirely recovered from, while the alexia remained. The question is, Why does the alexia in these

cases, although caused by the same lesion as the aphasia, remain longer than the latter. The answer might be suggested by the fact that normally the faculty of reading is built up upon the faculty of speech, as the child first learns speaking and then reading and writing. We might conclude in general that the memories of the muscular innervations required for the execution of articulate sounds are called up easier from the sound images than from the visual images of letters and words, and that the sound memories consequently form a firmer basis for the re-acquisition of the motor-speech memories. It must further be kept in mind that by hearing others speak the patient was constantly receiving auditory impressions without any voluntary effort on her part, while to re-learn reading would require special efforts, which in our case were certainly not made, as the patient never made any attempts at reading and writing after she had discovered her inability in that direction.

Although this explanation seems rational, it is contradicted by Déjerine and Mirallié's¹⁵ experience, according to which the patients affected with cortical motor aphasia usually recover sooner from the alexia than from the aphasia, being still distinctly aphasic at a time when the faculty of reading is fully restored. I must, therefore, leave the question unanswered why in our and many other cases the aphasia was sooner recovered from than the alexia.

In discussing the extent and nature of the lesion of Broca's centre two possibilities must be chiefly considered.

First.—The lesion might have been very extensive, destroying nearly the whole centre. This possibility may be rather safely excluded since it is highly improbable that in such cases an adult should so fully recover articulate speech within eight months after its loss.

Second.—The lesion of Broca's centre, which gave rise to the motor aphasia and the alexia and agraphia dependent upon it, might have been small or non-destructive. According to Freud, this would not cause a partial motor aphasia manifesting itself by the loss of a limited number of words, "but by a reduction in toto" of the entire motor speech centre. This functional reduction might show itself under one of the forms described by Bastian. The

¹⁵L. c.

motor-speech centre might, for instance, still be called up by association from other centres, but not by voluntary impulse; or they might still be called up from one centre, for instance, from the centre of the auditory images, but not from another, for instance, not from the centre of the visual word memories. Such a state could even have been produced by collateral changes due to a focus, not of the motor-speech centre itself, but of its vicinity. In our case the association of the motor-speech memories with the auditory memories of speech was already restored when the patient was first seen; but the association of the motor-speech centre with that of the visual word memories and its indirect association with the graphic motor memories was still defective; the patient, therefore, still presented distinct disturbances of the faculties of reading and writing. But these disturbances made indeed the impression, not of destroyed, but of only weakened function. This seemed evident from the following facts:

Neither the letters nor the words seemed absolutely foreign to the patient. She frequently did not recognize a letter or a word at first, but after long deliberation found it out correctly. She would be unable to read a letter in one word and would recognize it a few minutes afterwards in another one. She would further frequently manifest her inability to read a letter, not by saying that she did not know it, but by the remark, "I forget." Three letters, viz.: q, v and x, which could not be recognized spontaneously, were found out correctly by reciting the alphabet until the letter in question was reached. The fact finally that she made much more rapid progress in reading than could be expected if this faculty had to be acquired entirely anew, corroborates the view that the cerebral mechanism presiding over the said faculty was not destroyed but only weakened in its function, presenting one of the states referred to by Bastian.

The findings of the case reported offer opportunity for referring once more to the psychology of the act of reading. Wernicke¹⁶ and Grashey¹⁷ declare that reading is done spellingwise. The observations in our case would tend to prove that this statement is erroneous or too far

¹⁶L. c.

¹⁷Grashey: Ueber Aphasie und ihre Beziehungen zur Wahrnehmung. Arch. f. Psych., Bd. XVI., p. 654.

reaching, at least with regard to the English language. That our patient read most of the words as a whole, not by spelling, was shown by the following facts.¹⁸

1. Entire words were read more promptly than letters composing them.

2. Words which were read correctly were spelled wrongly.

3. The patient often spelled a posteriori from the sound of the word ("one" read correctly but spelled w-o-n, "unknown" read correctly but spelled u-n-w-n-o-w-n). In arriving at their conclusion that reading always occurs by spelling, Wernicke and Grashey evidently did not consider the peculiarities of the various languages, especially of the English. The varying enunciation of the same combination of consonants, or of vowels or of both, make it impossible to read English only spellingwise. It is enough to call to mind the threefold enunciation of the "ough," of the double enunciation of "ow," of the threefold manner of writing the sound "n" (n, kn, wn, etc.). It may further be mentioned that a new method of teaching is now in use in many schools, by which the children are taught to read words before learning the single letters. This method seems indeed more rational, as the

¹⁸The examination of the patient was made before I had read Thomas and Roux's interesting observations on the latent disturbances (troubles latents) of mental reading (*Travail du service du Dr. Dejerine à la Salpêtrière*. Bull. Soc. Biol., 1896, p. 210-213). The tests proposed by these authors were therefore not applied.

T. and R. conclude as follows:

"The alexia of the patients affected with cortical motor aphasia has some special characteristics. It is rare that the patient with cortical motor aphasia is completely alexic. He most frequently recognizes his Christian name, the name of his children, the name of usual objects. This number of "usual names" varies in proportion to the degree of the patient. The usual words are read, the unusual words are not understood by them, even if they are able to spell them.

"If the letters composing a usual word were written one above each other and at some distance of each other, but in the correct serial order, the patients were not able to read it, even when they could spell each single letter. They could read the word immediately, if it was presented to them in the usual aspect, that is with horizontal arrangement of the letters. But they also failed to understand a word, if each single letter of it was called out to them, one after the other. The authors refer these troubles directly to a change or complete loss of the faculty of mental spelling. 'This change or loss is, on the other hand, nothing but the consequence of the alterations of the associations between the auditory and the motor images.' That our case would have revealed similar disturbances, if the corresponding tests had been applied, seems highly probable."

visual word memories become thus directly associated with the formerly acquired sound memories and psychomotor images of the words. But even if reading was learned purely spellingwise one would learn to read as a whole those words which occur frequently. Many persons will read a language correctly and with great fluency and yet make numerous orthographical mistakes in writing, for the reason that certain combinations of letters are read as a whole and only the sound of them is remembered. "Enough" may be written "enuff," "though" may be written "thow." He who has learned a new language by grammar is less apt to make orthographical mistakes in writing than he who learned it directly from hearing; yet the latter may eventually read it much better than the former. I had opportunity to make some self-observations when I was learning Russian. The letters of this language were entirely foreign to me and I began to read before I was entirely familiar with them. Even now, if the single letters of the Russian alphabet were shown me one by one, out of alphabetical order, I should probably not recognize some of them at all, but if whole words were shown me I could read most of them without mistake, except in accentuation, because I should recognize some of the letters and half guess the rest from the sense. Although to a certain degree I had to learn the reading spellingwise, the memories of whole words read have become more firmly established than those of the letters composing them. I can easily read the words "Bechterew, Kowalewski, Neurological, Neuropathologist, central nervous system, university, and more words which, taken together, contain all the letters of the alphabet. I can read them easily because they occur frequently in the text I read. I can single them out on a page, yet when a new word occurs I have great difficulty in deciphering it. I may add, too, that, although the Russian types were perfectly foreign to me, my knowledge of the Polish language made it much easier for me to learn to read Russian than it would have been to an Englishman, Frenchman or German, because the Russian language resembles the Polish much in sound, although in type it differs materially from it. In the Polish language Latin characters are used.

It remains to explain one peculiarity of the case, name-

ly, that the patient invariably used printed characters instead of script in writing. I believe this peculiarity is due to the loss of the motor-graphic memories, id est of the memories of the motor concepts presiding over the technique of writing written characters. Pitres,¹⁹ Charcot²⁰ and others claim the existence of a special graphic centre, homologous to the motor-speech centre. Some authors locate this centre in the second frontal convolution. Sachs²¹ and others consider it as a part of the arm centre.

Pitres reports a case of motor agraphia which is of especial interest, as it presented this disturbance in its purest type. It concerned a patient who was struck with hemiplegia, loss of consciousness, etc., with subsequent aphasic symptoms. The attack was probably of syphilitic origin. The general symptoms yielded promptly to mercury treatment, the local manifestations subsided gradually. Half a year after the attack the patient could walk without aid. One year and a half after the onset of the disease he came under Pitres' observation, who found the following condition:

"No disturbances whatever of speech and of reading. The right hand shows only very slight motor disturbances, yet the patient is unable to write anything spontaneously or from dictation with this hand. With the left hand he writes quite well from copy, to dictation and spontaneously. The word "souvenir" is dictated and the patient asked to write it with the right hand; he is unable to do so, but he writes the word with the left hand and is then able to copy with the right hand what the left has written. This alone proves that the impossibility of writing is not due to any mechanical difficulty. He can also copy with the right hand what somebody else writes in script. If, however, he has to copy with this hand from printed text he can only reproduce it in print-types, not in script, while in copying with the left hand he directly transmits the printed characters into written signs.

Pitres justly explains the case of assuming loss of the memories of the combinations of muscular efforts required

¹⁹A. Pitres: *Considérations sur l'agraphie à propos d'une observation nouvelle d'agraphie motrice pure*. *Revue de Méd.*, 1884.

²⁰Charcot: Quoted from Pitres, l. c.

²¹Sachs, l. c.

for the tracing of written characters. He further concludes that as a distinction is made between glossoplegia and logoplegia there should also be one between brachoplegia and graphoplegia, and motor agraphia should be considered as a homologon of motor aphasia.

Our case differed from that of Pitres in as much as our patient showed the same graphic disturbances, although in less degree, in the left hand, which Pitres' patient presented in the right hand. In our case there was such an extreme degree of paralysis of the right hand and finger-muscles with extreme contracture of these parts, that writing with the right hand was out of the question. If by some mechanical contrivance the patient would have been enabled to write with the right upper extremity it would only have been a writing with the whole arm. Such test was not made and would not have been of much clinical importance.

With the left hand the patient wrote only in printed characters both from dictation and in copying from printed text. Although she was not absolutely unable to reproduce script, she had so much more difficulty in using written signs that she never attempted to do so except on special request. In most languages the signs commonly used in print differ from those used in writing. Most people read principally from printed text while they write in written characters, which for English-speaking people are like the Latin. Written symbols are much less frequently read from than printed characters, for which reason the visual memories of printed signs are on the average much better established than those of script. On the other hand, by using only script in writing we develop by practice a special technique, a great skill and rapidity in the execution of these characters. The acquirement of such skill is due chiefly to a fine organization of that cerebral apparatus which presides over the co-ordination of the graphic motions. This co-ordination is guided partly by visual impressions, as we can control our graphic movements with the eye, but still much more by muscular sensations. That the latter play a very important part is evident from the fact that we can write quite well with the eyes closed, that we make very few mistakes in so doing, and that the technical execution of the letters and words thus written is nearly as good as when we write with the

eyes open. The muscular sensations accompanying our graphic movements leave memories which with practice become more and more strengthened and enable a rapid selective innervation of certain groups of cells, the combined excitation of which will produce one definite movement; they also enable a serial innervation of the whole series of muscular efforts required to execute a particular letter. If we are warranted in speaking of a motor-speech centre, we must also be justified in speaking, if not of a centre, yet at least of a physiological apparatus in which the said muscular graphic memories are stored. Loss of these memories need not imply the absolute impossibility of writing in written types, as the visual memories may supply the loss sustained. Usually, however, the visual memories of written types are very dim, 1st, because written types are, as a rule, much less frequently read from; 2d, because they are usually much more varying in shape, since one person has an absolutely different character of writing than the other and since even the same individual may show a great variety in the execution of one and the same letter. Consequently, individuals who have lost the muscular graphic memories will show great difficulty, if not inability, of executing written characters spontaneously or from dictation, while the faculty of purely mechanical copying such characters will be preserved. These disturbances will, of course, be much less marked in a person who does much writing and much reading of written text. Here the assistance of the visual memories will greatly mask the loss of the muscular memories.

Ordinarily, we learn to write with the right hand, and thus develop a graphic mechanism in the left hemisphere. Our first trials to write with the left hand succeed badly, as we have only visual memories to guide us. But if the hand becomes disabled, say from a fracture, for instance, we may learn to write with the left hand, as well as we did with the right, by developing a graphic apparatus in the right hemisphere. This, probably, explains the condition in Pitres' case. The patient, after having fully recovered the faculty of speech, began to practice the left hand for writing when his right one was still much paralyzed. Our patient had never tried to write with the left hand. If she had, she probably would have attained the same faculty as Pitres' pa-

tient, and the latter would probably also reestablish a motor-graphic apparatus in the left hemisphere, as he possessed the mechanical faculty of executing the characters with the right hand, if he did not find it more convenient to continue using his left hand, with which he had evidently attained considerable practice.²²

In speaking of a graphic-motor apparatus it is not meant to convey the impression as if such formed an anatomically circumscribed centre. There can only be question of a physiological, not of an anatomical, unity. In other words, it is not supposed that a lesion may just destroy the motor graphic memories and leave intact all the motor memories presiding over other technical faculties of the hand and finger muscles. On the contrary, it is supposed that such other memories are stored at least partly within the same area, presumably the arm centre and its vicinity. But there must be anatomically to a certain degree a separation between a more elementary and a higher organized motor apparatus, the latter being perhaps represented in the superficial, the former in the deeper strata of the cortex, presumably in the large pyramidal cells.

Some remark is still in order regarding the effects of lesions of Broca's centre upon the high mental faculties. It is usually supposed that loss of the motor speech memories need not cause any disturbances of intelligence. This view seemingly finds support in the fact that deaf mutes, who do not develop a motor-speech centre can yet exhibit high degrees of intelligence. This, however, only proves that the mental processes of these individuals become otherwise arranged, otherwise organized. Their higher conceptions are chiefly built up from visual impressions, and they express their thoughts chiefly by muscular and visual memories. As the motions of the fingers form a very essential part of the apparatus by means of which

²²Dejerine interprets Pitres' case otherwise. He ascribes the agraphia to an interruption of an association between the arm centre and the angular gyrus of the left hemisphere, which implies that according to his view the graphic images are innervated directly from the visual images. It is much more probable, however, that they are evoked from the auditory images in the manner described on page 111. The hemianopsia which Pitres' case presented could not explain the agraphia. As this hemianopsia was not accompanied by alexia, it is difficult to conceive that it should have been in causal connection with the agraphia.

deaf mutes express their thoughts, a centre probably forms which assumes such a dignity over the arm and, especially, the hand centre as in normally organized brains the speech centre does over the face, tongue, larynx and pharynx centres. In a person with a normally organized brain, however, the process of thinking occurs predominantly by way of the motor and sensory speech centres, we think chiefly speakingly. The synthetic mental faculties especially are greatly dependent upon the intactness of the speech apparatus. It has been shown that in reading the visual word memories innervate directly the motor-speech memories, which latter evoke the sound memories of the words. "We speak inwardly what we read," and can only thus form conceptions of what we read. In case of lesion of Broca's centre this internal language becomes impossible and the text before the eye of the patient has, accordingly, no meaning for him; a very important source of forming new conceptions is thus cut off. Another very important source is given in the auditory impressions which we receive. The patient with a lesion of Broca's centre can understand what is said to him, but he has lost the power of inwardly repeating what was said and is thus robbed of an important means for establishing landmarks of what he heard, that is, of fastening his attention upon the salient points, and thus forming abstracts of the contents of heard language. In short, the motor-speech centre forms such an important factor in the evolution of the higher mental processes that its lesion cannot remain without damaging influence upon the mental activity. As it also has exquisitely the function of co-ordinating and fusing sensory memories (for instance, visual in reading, auditory in writing from dictation) with memories of motor innervation (for instance, reading, writing) we can understand its location in the frontal lobe. We see at the same time that the physiology and psychology of Broca's centre, as related, corroborates Bianchi's theory regarding the function of the frontal lobe to which that centre belongs.